Impact of Exchange Rate on Gold Price in India

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Abstract
In this article we investigate the impact of rupee-dollar exchange rates on growth rate of gold price in India over the period 1970-2016. The investigation is done using some steps. In the first step we use Augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) test to detect that the series is stationary or not. To show the long run association of the variables we apply Johansen Co-integration test. As there is no cointegration we apply unrestricted VAR method. Since the study variables are not cointegrated, there is no long run causality, there is only short run causality running from independent variables to dependent variables. Further the Granger Causality test determines whether growth rate of gold price depends on the growth rate of rupee dollar exchange rate or not. At last we also test the stability of the model using Eigen value statistic method. The main finding of this paper is that growth rate of gold price depends negatively and significantly on growth of rupee dollar exchange rate, means that as rupee dollar exchange rate rises gold price decreases and vice versa. The study also shows that growth rate of gold price does not Granger cause to rupee-dollar exchange rate where as rupee-dollar exchange rate Granger cause to gold price in Indian economy. That is we can stabilise the Gold Price movement by controlling the exchange rate fluctuations.

Keywords: gold price, rupee-dollar exchange rates, Co-integration, Vector Auto Regression, Granger causality

1. Introduction
From the traditional days gold has its importance. It has been a symbol of status in the society and considered to be an instrument of investment by the people. Though gold is not considered as a primary form of currency in all countries, it has a significant influence on the value of those currencies too. There exist a correlation between the value of gold and the currencies of any country. Gold market and Foreign exchange market both provides better opportunities for investment so they attract the investors. Today, India is the largest gold importer. By the end of the Dec 2017, Indian gold import will increase to 700 tonnes and earlier it was 500 tonnes in 2016-17. There is an inverse relationship between the value of rupee-dollar exchange rate and that of gold price. Dollar is an internationally accepted currency and most of the international transactions take place in terms of dollar. The major reason behind the inverse relationship between gold price and rupee-dollar exchange rates is that as the dollar’s exchange value decreases, it takes more dollars to buy gold, which increases the value of gold. As a result gold price increases. The fluctuation of the value of dollar depends on several factors like shifts in monetary policy, international trade, etc., but the gold price is largely determined by its supply and demand. Now-a-days the investment behaviour of Indian population is observed to be changing. They think that investment in gold is a safe option. The volatility of market panics the investors and makes the investment decisions difficult and risky. In this context, the present paper is an attempt to examine the causal relationship between gold price movement and rupee-dollar exchange rate movement in the Indian context.

Objective of the Study
The main objectives of this study are:
- To analyse the relationship between growth rate of gold price and rupee dollar exchange rate.
To analyse whether the relationships are long run or short run phenomena, or both.

To analyse whether there is any causal relationships between growth rate of gold price and rupee dollar exchange rate.

To analyse the directions of the causality between growth rate of gold price and rupee dollar exchange rate.

Sources of Data
In this study we use secondary data cover annual time series of 1970 to 2016 (or 45 observations) in Indian economy. The data set consists of observations for gold price (Rupees per 10 grams in Mumbai) and rupee-dollar exchange rates. Maximum data were collected from ‘Hand Book of statistics on the Indian Economy’ (RBI) in the year 2010-11 and 2017-18. Apart from we use the official website of Multi Commodity Exchange Limited (MCX), a leading commodity exchange for metal trade in India.

Methodology
We have considered two important variables which are gold price (GP), and rupee dollar exchange rate (D) in India from the year 1970 to 2016. Before analyzing the relationship between gold price and rupee dollar exchange rate, data has been transformed into natural logarithms. In this paper the relationship is explained by using some steps.

- In section I, we test whether the study variables contains unit roots or not. The stationary of each series is tested by using Augmented Dickey Fuller method and Phillips Perron method.

- In section II, we conduct lag selection method. By this method we determine the number of lag appropriate to estimate the model. To estimate the model the number of lagged differences included is determined by the LR, FPE, HQIC, SBIC and AIC method.

- In section III, we detect whether there is a long run relationship exists or not. This is done by using Johansen test of co-integration.

In section IV, we estimate the model using unrestricted VAR method, and then we use Granger Causality test to detect whether as a whole all the lags of the independent variable affect the dependent variable or not.

In section V, we explain the stability of the unrestricted VAR model using the method of Eigen value. We also explain impulse response factor and variance decomposition method in this section.

Finally in section VI we explain residual diagnostic tests. There are different types of residual diagnostic test like the test for autocorrelation, test for normally distributed residuals, and tests for no heteroscedasticity problem.

Model Specification
For the present study the following model has been used.

GP = f (ER)

In log linear form the model can be written as

LGP = β₀ + β₁LER + C₁

Where,

LGP = Logarithmic value of Gold Price
LER = Logarithmic value of Rupee-Dollar exchange rate.
β₀ = autonomous part or constant term.
β₁ = slope coefficient.
C₁ = Random Error Term.

The slope coefficients β₁ represent how one percent change in rupee-dollar exchange rates affects the percentage change in gold price.

Results and discussion
Section I

- Trend and growth rate of gold price and rupee-dollar exchange rates:

The following figures show the trend and growth rate of gold price and rupee dollar exchange rate.

Fig 1: The trend in gold price and rupee dollar exchange rate of India
Results of Unit Roots Tests

To check the stationarity of a time series data there are several tests. In this paper to check the stationary of the study variables we conduct Augmented Dickey Fuller test. For double checking we also perform Phillips-Perron test. In both the tests the null hypothesis is $H_0$: Presence of unit root or the series is non-stationary. Against the alternative hypothesis $H_1$: Absence of unit root or the series is stationary.

If the value of the test statistic is less than 5% critical value or if the p-value is greater than 5% we accept the null hypothesis that there is a unit root and the series is non-stationary, otherwise the series the stationary.

After applying unit root test the results are as follows:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test Statistics</th>
<th>p-value</th>
<th>Test statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LGP</td>
<td>Z(rho) = - 1.404</td>
<td>0.3689</td>
<td>Z(rho) = - 24.168</td>
<td>0.0013</td>
</tr>
<tr>
<td></td>
<td>Z(t)= - 1.824</td>
<td></td>
<td>Z(t)= - 4.019</td>
<td></td>
</tr>
<tr>
<td>LER</td>
<td>Z(rho) = - 0.274</td>
<td>0.9204</td>
<td>Z(rho) = - 31.391</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>Z(t)= - 0.335</td>
<td></td>
<td>Z(t)= - 4.711</td>
<td></td>
</tr>
</tbody>
</table>

Source: Author’s computation using STATA 14 Econometric software.

From the table, we see that LGP and LER are non-stationary in level but after first difference they become stationary. Therefore, it may conclude that all the variables are integrated of order 1. Since the variables are stationary in first difference, the next step is to judge the long run association among the variables by conducting co-integration test. If there is co-integration among the variables we say that the variables have long run association i.e there is a long run relationship between the variables.

Results of Lag Selection Method:

Before conducting co-integration test at first we have to find out how many lag should be used for estimating the model. Determination of lag length is an important factor because larger the Lag Intervals for the variables the more it can reflect the dynamic nature of the model. The results of the lag selection method are as follows:

<table>
<thead>
<tr>
<th>lag</th>
<th>LR</th>
<th>df</th>
<th>P</th>
<th>FPE</th>
<th>AIC</th>
<th>HQIC</th>
<th>SBIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-8.04889</td>
<td>4</td>
<td>0.000</td>
<td>.005471</td>
<td>0.46739</td>
<td>0.497599</td>
<td>0.549307</td>
</tr>
<tr>
<td>1</td>
<td>162.802</td>
<td>341.7</td>
<td>4</td>
<td>2.3e-06</td>
<td>-7.29313</td>
<td>-7.20251</td>
<td>-7.04738</td>
</tr>
<tr>
<td>2</td>
<td>176.621</td>
<td>27.637*</td>
<td>4</td>
<td>0.000</td>
<td>1.5e-06*</td>
<td>-7.7498*</td>
<td>-7.59876*</td>
</tr>
<tr>
<td>3</td>
<td>179.898</td>
<td>6.5538</td>
<td>4</td>
<td>0.161</td>
<td>1.5e-06</td>
<td>-7.71617</td>
<td>-7.50471</td>
</tr>
<tr>
<td>4</td>
<td>182.992</td>
<td>6.1893</td>
<td>4</td>
<td>0.185</td>
<td>1.6e-06</td>
<td>-7.67406</td>
<td>-7.40218</td>
</tr>
</tbody>
</table>

Source: Author’s computation using STATA 14, Econometric softare

LR: sequential modified LR test statistic, H&Q: Hannan-Quinn information criterion, FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion

From the table we see that according to LR, FPE, AIC, HQIC and SBIC lag should be 2. So, after the comparing of Lag Length Criteria, it is found that the optimal lag order for the model is 2.
Section –III

• Johansen Co-integration Test:
To test whether there is a long run association or not among the study variables we conduct Johansen test of co-
integration. In Johansen test there are two statistic (i) Trace Statistic and (ii) Maximum Eigen value Statistics. To test
the validity of the co-integration let the null hypothesis is H0: There is no co-integration. Against the alternative hypothesis
H1: There is co-integration.
If the value of the test statistic (Trace Statistic or Maximum Eigen value Statistics) is greater than the critical value at 5%
level of significance then we can reject the null hypothesis and conclude that there is co-integration among the study
variables. After applying Johansen co-integration test the results are as follows:

<table>
<thead>
<tr>
<th>Max. Rank</th>
<th>Trace Statistic</th>
<th>Max Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Value</td>
<td>5% critical value</td>
</tr>
<tr>
<td>0</td>
<td>11.1745*</td>
<td>15.41</td>
</tr>
<tr>
<td>1</td>
<td>3.1118</td>
<td>3.76</td>
</tr>
</tbody>
</table>

Source: Author’s computation using STATA 14 Econometric soft ware

From the above table we see that the value of trace statistic is lower than 5% critical value at rank 0. So we can accept
the null hypothesis and say that there is no co-integration among the variables.
We get the same result from the maximum Eigen value statistics. The value of the maximum Eigen value statistics at
rank 0 is 6.7490 which is lower than the tabulated value. So we can accept the null hypothesis and say that there is no
long run association among the study variables.

Section –IV

• VAR Analysis
In VAR model there are two issues: long run causality and short run causality. Since the variables are not co-integrated,
so there is no long run causality, there is only short run causality running from independent variables to dependent
variables. Here all the coefficients are short run coefficient.

The result of the VAR analysis is explained below.

<table>
<thead>
<tr>
<th>Variable affecting D_LGP</th>
<th>Coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>First lag of LGP</td>
<td>0.5244224</td>
<td>0.000</td>
</tr>
<tr>
<td>Second lag of LGP</td>
<td>-0.2176267</td>
<td>0.085</td>
</tr>
<tr>
<td>First lag of LER</td>
<td>-0.9809253</td>
<td>0.000</td>
</tr>
<tr>
<td>Second lag of LER</td>
<td>0.3010936</td>
<td>0.229</td>
</tr>
<tr>
<td>Constant</td>
<td>0.0474276</td>
<td>0.000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable affecting D_LER</th>
<th>Coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>First lag of LER</td>
<td>0.3108992</td>
<td>0.213</td>
</tr>
<tr>
<td>Second lag of LER</td>
<td>0.1057895</td>
<td>0.054</td>
</tr>
<tr>
<td>First lag of LEP</td>
<td>-0.11906</td>
<td>0.030</td>
</tr>
<tr>
<td>Second lag of LEP</td>
<td>0.1612594</td>
<td>0.523</td>
</tr>
<tr>
<td>Constant</td>
<td>0.0105993</td>
<td>0.204</td>
</tr>
</tbody>
</table>

Source: Author’s computation using STATA 1, Econometric soft ware

From the above table it is clear that the growth rate of GP significantly depends on the first lag of rupee-dollar
exchange rates. This relationship is negative, and the result is significant (*). The growth of GP also depends on the
second lag of rupee-dollar exchange rates. This relationship is also positive. But, the result is not significant. So, from
the above result we say that there is a negative relationship between growth rate of gold price and rupee-dollar
exchange rates. As exchange rate increases gold price will decrease. The inverse relation may exist because of the
following reasons:

• When the value of the US dollar decreases the investor will look for alternative sources of investment to store
  their value, and in this situation gold is an alternative. As the demand for gold increases its price will also
  increase.
• When the value of the US dollar decreases the value of the currencies of other countries will increase. This will
  increase the demand for all commodities including gold.
• When inflation occurs in an economy the value of currencies goes down. In this situation individual tried to
  hold money in the form of gold. As a result demand for gold will increase and this will push gold price higher.
• In some countries like India due to excess demand, gold is imported and hence if the rupee weakens against the
  dollar, gold price will increases in rupee form.

• Granger Causality Test
Granger causality test tells us whether as a whole all the lags of the independent variable affect the dependent variable or
not. At first we set two hypotheses. The null hypothesis is H0: lag independent variable does not cause the dependent
variable Against the alternative hypothesis H1: lagged independent variable cause dependent variable.
The following table depicts the results of the Granger Causality Wald test:

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>Chi square value</th>
<th>df</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>D_LER does not cause D_LGP</td>
<td>20.482</td>
<td>2</td>
<td>0.000</td>
</tr>
<tr>
<td>D_LGP does not cause D_LER</td>
<td>3.9587</td>
<td>2</td>
<td>0.138</td>
</tr>
</tbody>
</table>

Source: Author’s computation using STATA 14 Econometric soft ware

From the result we say that all the lagged value of rupee-dollar exchange rates can cause GP. In this case chi square
value is 20.482 and corresponding p value is 0.000. Since the p value is less than 5% level of significance means that
we can reject the null hypothesis that D_LER does not cause D_LGP. On the other hand all the lagged value of
growth of gold price cannot cause rupee dollar exchange rate. In this case chi square value is 3.9587 and corresponding
p value is 0.138. Since the p value is more than 5% level of significance means that we can accept the
null hypothesis that D_LGP does not cause D_LER. Thus the causality test indicates that rupee-dollar exchange rates
significantly influence the growth of gold price in Indian economy.

Section –V

• Stability of the VAR Model
In this study we conduct the test for stability of the estimated VAR model. We use Eigen value stability
condition. It is seen that the modulus of all roots are less than unity and lie within the unit circle as shown in the
following table and figure.
So our estimated VAR model is stable.

- **Impulse Response Function:**
  Impulse response function is a shock to a VAR model. When we estimating a VAR model there may be a large number of estimated parameters. For this we cannot interpret the parameters properly. To overcome this problem we use impulse response function. The impulse response function trace out the responses of the dependent variable when there is a shock. More specifically, by impulses we mean a factor which will give a shock. On the other hand by responses means how the other variables will be reacting for this shock. The graphs of the impulse responses are shown below.
The solid horizontal line is a zero line. When we go up to this line means there is positive shock, and when we go below the line means there is a negative shock. To explain the concept we chose 10 years into the future. First consider the response of D_(LGP) to D_(LER), means that if there is a positive shock of one s.d to log GP, how it will affect its own value. Here the blue line is the reaction pattern. So we can say that its own value gradually decreases and then becomes closer to zero. In other words after 6 years reaction becomes zero.

Now consider the response of D_(LGP) to D_(LER), means that if there is a positive shock of one s.d to log D, how it will affect D_(LGP). We can say that its value initially decreases and then increases but after 6 years the value comes closer to zero. In other words after 6 years reaction becomes zero.

We can also explain the response of D_(LGP) to D_(LGP), means that if there is a positive shock of one s.d to log GP, how it will affect D_(LGP). We can say that its own value initially decreases and then increases but after 10 years the reaction becomes zero.

Consider the response of D_(LER) to D_(LGP), means that if there is a positive shock of one s.d to log D, how it will affect D_(LER). We can say that its value gradually decreases and then becomes zero. In other words after 10 years reaction becomes zero.

\section{Variance Decomposition:}

In a VAR model, there is an alternative method to determine the effects of shocks to the dependent variables. This is known as variance decomposition method. The technique determines how much of the forecast error variance for any variable is explained by shocks in each explanatory variable over a series of time horizon. In this method it is necessary to choose an ordering of the variables. There are different methods for this purpose but we use Cholesky decomposition method. The result of the variance decomposition is shown in the following table:

<table>
<thead>
<tr>
<th>Lag</th>
<th>Chi square</th>
<th>Df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.2366</td>
<td>4</td>
<td>0.51904</td>
</tr>
<tr>
<td>2</td>
<td>5.0520</td>
<td>4</td>
<td>0.28200</td>
</tr>
</tbody>
</table>

From the table we see that at lag 1 the value of chi-square at 4 df is 3.2366 and corresponding p-value is 0.51904. Since the p-value is more than 5% so we can accept the null hypothesis that there is no autocorrelation problem. Again at lag 2 the value of chi-square at 4 df is 5.0520 and corresponding p-value is 0.28200. Since the p-value is more than 5% so we can accept the null hypothesis that there is no autocorrelation problem.

\section{Test for Heteroscedasticity:}

To test that the variance of the residual is constant in the model we use Breusch-Pagan-Godfrey test. Here the null hypothesis is 

\text{H}_0: \text{There is no heteroscedasticity problem.}

Against the alternative hypothesis

\text{H}_1: \text{There is a problem of heteroscedasticity}

The resulting Breusch-Pagan-Godfrey test is shown in the following table:

<table>
<thead>
<tr>
<th>Chi square</th>
<th>Df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.60577</td>
<td>24</td>
<td>0.8217</td>
</tr>
</tbody>
</table>

From the table we see that the value of chi-square at 24 df is 17.60577 and corresponding p-value is 0.8217. Since the p-value is more than 5%, we can accept the null hypothesis that variance of the residuals are constant or there is no heteroscedasticity problem.

\section{Test for Normality of the Residuals:}

To test that the residuals are normally distributed in the VAR model we can use Jarque - Bera test. The Jarque - Bera statistic follows chi-square distribution. Here the null hypothesis is
$H_0$: residuals are normally distributed.
Against the alternative hypothesis
$H_1$: residuals are not normally distributed.
The result of Jarque Bera test is shown in the following table

<table>
<thead>
<tr>
<th>Equation</th>
<th>Chi square</th>
<th>Df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>D_LGP</td>
<td>0.308</td>
<td>2</td>
<td>0.85746</td>
</tr>
<tr>
<td>D LER</td>
<td>5.501</td>
<td>2</td>
<td>0.06390</td>
</tr>
<tr>
<td>ALL</td>
<td>5.808</td>
<td>4</td>
<td>0.21392</td>
</tr>
</tbody>
</table>

From the above result we say that the residuals are normally distributed. In this case the p-value is greater than 5%, so there is no reason to reject the null hypothesis and infer that the residuals of D_log GP are normally distributed.

**Conclusion**

In this paper, we have examined the relationship between gold price and rupee dollar exchange rate in India using time series data from 1970 to 2016. In other words we want to check how rate of change of rupee dollar exchange rate affect the growth rate of gold price in India. This study uses the ADF unit root test, Johansen test for co-integration, VAR analysis and Granger causality test. The stable VAR model shows that in between the periods 1970 and 2016 the growth rate of gold price in India depended significantly and negatively on the rupee dollar exchange rate. VAR analysis is done on the growth levels of the two variables. It is seen that the growth of gold price significantly depends only on the first lag of rupee-dollar exchange rates. This relationship is negative, and the result is also significant. The growth of gold price also depends on the second lag of rupee-dollar exchange rates. This relationship is also negative. But, the result is not significant. We say that there is a negative relationship between growth of gold price and rupee-dollar exchange rates. As exchange rate increases gold price will decrease. The causality test indicates that rupee dollar exchange rate influence the gold price of the Indian economy. Since the variables are not co-integrated, so there is no long run causality, there is only short run causality running from independent variables to dependent variables.

**References**

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